

Industrial thermoprocessing equipment

Part 2: Safety requirements for combustion and fuel handling systems

ICS 25.180.01

National foreword

This British Standard is the UK implementation of EN 746-2:2010. It supersedes BS EN 746-2:1997 which will be withdrawn on 31 May 2011.

The UK participation in its preparation was entrusted to Technical Committee MCE/3/8, Thermoprocessing equipment - Safety.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

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Industrial thermoprocessing equipment - Safety requirements for combustion and fuel handling systems

Equipements thermiques industriels - Partie 2:
Prescriptions de sécurité concernant la combustion et la
manutention des combustibles

Industrielle Thermoprozessanlagen - Teil 2:
Sicherheitsanforderungen an Feuerungen und
Brennstoffführungssysteme

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Management Centre: Avenue Marnix 17, B-1000 Brussels

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Foreword

This document (EN 746-2:2010) has been prepared by Technical Committee CEN/TC 186 “Industrial Thermoprocessing Equipment”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by November 2010, and conflicting national standards shall be withdrawn at the latest by May 2011.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 746-2:1997.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For relationship with EU Directive(s), see informative Annex ZA, which is an integral part of this document.

Following a request from CEN/TC 186, CEN has agreed to defer the date of withdrawal of EN 746-2:1997 for a transitional period of 12 months.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

Introduction

This European Standard is a Type C standard as defined in EN ISO 12100-1.

The machinery concerned and the extent to which hazards, hazardous situations and events are covered, is indicated in the scope of this document.

When provisions of this type C standard are different from those which are stated in type A or B standards, the provisions of this type C standard take precedence over the provisions of the other standards, for machines that have been designed and built according to the provisions of this type C standard.

This Part of EN 746 assumes that the equipment is not creating any potentially explosive atmosphere and is located in a normally ventilated area.

This European Standard forms one part of a series of safety standards covering Industrial Thermoprocessing Equipment (IThE). The full list of these standards is given below:

EN 746, *Industrial thermoprocessing equipment*

- Part 1: Common safety requirements for industrial thermoprocessing equipment
- Part 2: Safety requirements for combustion and fuel handling systems
- Part 3: Safety requirements for the generation and use of atmosphere gases
- Part 4: Particular safety requirements for hot dip galvanising thermoprocessing equipment
- Part 5: Particular safety requirements for salt bath thermoprocessing equipment
- Part 6: Particular safety requirements for material melting, re-melting and liquid phase maintaining thermoprocessing equipment
- Part 7: Particular safety requirements for vacuum thermoprocessing equipment
- Part 8: Particular safety requirements for quenching equipment

Compliance with European product standards e.g. EN 267, EN 12952-8, EN 12953-7 or EN 676 is not sufficient to ensure the minimum safety requirement for industrial thermoprocessing equipment. This part 2 of EN 746 shall always have priority for IThE.

An IThE generally consists of the following components:

- processing chamber (e.g. steel construction with lining);
- heating system;
- protective system;
- control and instrumentation system/operator-control level.

It is assumed that (IThE) will only be operated and maintained by trained personnel.

1 Scope

This part of EN 746 together with EN 746-1 specifies safety requirements for single and multiple burners that are part of Industrial Thermoprocessing Equipment. (In this standard referred to as IThE).

This document deals with significant hazards, hazardous situations and events relevant to combustion and fuel handling systems that are part of IThE as listed in Clause 4, when used as intended and under the conditions foreseen by the manufacturer.

This European Standard covers:

- fuel pipework downstream of and including the manual isolating valve;
- burner(s), burner system and ignition device;
- safety related control system (protective system).

This European Standard applies to any oxidation with air or other gases containing free oxygen of gaseous, liquid and solid fuels or any combustion of them to release thermal energy.

For thermal or catalytic post combustion and waste incineration, this European Standard applies only to auxiliary burners designed to start-up and/or support the process.

The pressure hazard of the piping and components covered by this standard is within the limits of maximum pressure/size relationship as described in normative Annex E.

This European Standard also gives the necessary requirements for the information for use.

This European Standard does not cover hazards from heating generated by electricity.

This European Standard does not deal with the hazards created by the release of flammable substances from the products processed in the IThE.

NOTE EN 1539, *Dryers and ovens, in which flammable substances are released — Safety requirements*

This European Standard is not applicable to combustion and fuel handling systems

- of welding and soldering machines;
- up-stream of the IThE manual isolating valve.

This European Standard is not applicable to electricity cabling and power cabling upstream of the IThE control panel/protective system.

Noise can be a significant hazard for combustion and fuel handling systems. It is not dealt with in this standard.

This European Standard is not applicable to combustion and fuel handling systems as part of IThE which is manufactured before the date of its publication as EN.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 88-1:2007, *Pressure regulators and associated safety devices for gas appliances — Part 1: Pressure regulators for inlet pressures up to and including 500 mbar*

EN 88-2:2007, *Pressure regulators and associated safety devices for gas appliances — Part 2: Pressure regulators for inlet pressures above 500 mbar up to and including 5 bar*

EN 125:1991, *Flame supervision devices for gas burning appliances — Thermo-electric flame supervision devices*

EN 161:2007, *Automatic shut-off valves for gas burners and gas appliances*

EN 230:2005, *Automatic burner control systems for oil burners*

EN 264:1991, *Safety shut-off devices for combustion plants using liquid fuels — Safety requirements and testing*

EN 298:2003, *Automatic gas burner control systems for gas burners and gas burning appliances with or without fans*

EN 331:1998, *Manually operated ball valves and closed bottom taper plug valves for gas installations for buildings*

EN 334:2005, *Gas pressure regulators for inlet pressures up to 100 bar*

EN 751-1:1996, *Sealing materials for metallic threaded joints in contact with 1st, 2nd and 3rd family gases and hot water — Part 1: Anaerobic jointing compounds*

EN 751-2:1996, *Sealing materials for metallic threaded joints in contact with 1st, 2nd and 3rd family gases and hot water — Part 2: Non-hardening jointing compounds*

EN 1057:2006, *Copper and copper alloys — Seamless, round copper tubes for water and gas in sanitary and heating applications*

EN 1643:2000, *Valve proving systems for automatic shut-off valves for gas burners and gas appliances*

EN 1854:2006, *Pressure sensing devices for gas burners and gas burning appliances*

EN 10241:2000, *Steel threaded pipe fittings*

EN 10242:1995, *Threaded pipe fittings in malleable cast iron*

EN 12067-1:1998, *Gas/air ratio controls for gas burners and gas burning appliances — Part 1: Pneumatic types*

EN 12067-2:2004, *Gas/air ratio controls for gas burners and gas burning appliances — Part 2: Electronic types*

EN 12078:1998, *Zero governors for gas burners and gas burning appliances*

EN 14382:2005, *Safety devices for gas pressure regulating stations and installations — Gas safety shut-off devices for inlet pressure up to 100 bar*

EN 60204-1:2006, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements (IEC 60204-1:2005, modified)*

EN 60664 -1:2007, *Insulation coordination for equipment within low-voltage systems — Part 1: Principles, requirements and tests (IEC 60664-1:2007)*

EN 60947-4-1:2001, *Low-voltage switchgear and controlgear — Part 4-1: Contactors and motor-starters; Electromechanical contactors and motor-starters (IEC 60947-4-1:2000)*

EN 61140:2002, *Protection against electric shock - Common aspects for installation and equipment (IEC 61140:2001)*

EN 61558-1:2005, *Safety of power transformers, power supplies, reactors and similar products — Part 1: General requirements and tests (IEC 61558-1:2005)*

EN 61810-1:2008, *Electromechanical elementary relays — Part 1: General requirements (IEC 61810-1:2008)*

EN 62061:2005, *Safety of machinery — Functional safety of safety-related electrical, electronic and programmable electronic control systems (IEC 62061:2005)*

EN ISO 5817:2007, *Welding — Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) — Quality levels for imperfections (ISO 5817:2003, corrected version:2005, including Technical Corrigendum 1:2006)*

EN ISO 8434-1:2007, *Metallic tube connections for fluid power and general use — Part 1: 24 degree cone connectors (ISO 8434-1:2007)*

EN ISO 8434-4:2000, *Metallic tube connections for fluid power and general use — Part 4: 24° cone connectors with O-ring weld-on nipples (ISO 8434-4:1995)*

EN ISO 12100-1, *Safety of machinery — Basic concepts, general principles for design — Part 1: Basic terminology, methodology (ISO 12100-1:2003)*

EN ISO 12100-2, *Safety of machinery — Basic concepts, general principles for design — Part 2: Technical principles and specifications (ISO 12100-2:2003)*

EN ISO 13849-1:2008, *Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design (ISO 13849-1:2006)*

EN ISO 19879:2005, *Metallic tube connections for fluid power and general use — Part 5: Test methods for hydraulic fluid power connections (ISO 19879:2005)*

ISO 7-1:1994, *Pipe threads where pressure-tight joints are made on the threads — Part 1: Dimensions, tolerances and designation*

ISO 228-1:2000, *Pipe threads where pressure-tight joints are not made on the threads — Part 1: Dimensions, tolerances and designation*

ISO 6976:1995, *Natural gas — Calculation of caloric values, density, relative density and Wobbe index from composition*

ISO 7005-1:1992, *Metallic flanges — Part 1: Steel flanges*

ISO 7005-2:1988, *Metallic flanges — Part 2: Cast iron flanges*

ISO 7005-3:1988, *Metallic flanges — Part 3: Copper alloy and composite flanges*

ISO 8434-2:1994, *Metallic tube fittings for fluid power and general use — Part 2: 37 degree flared connectors*

ISO 8434-3:2005, *Metallic tube connections for fluid power and general use — Part 3: O-ring face seal fittings*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

NOTE 1 A classification of plant, fuels and burners is given in informative Annex A.

NOTE 2 An alphabetic listing of technical terms in German, French and English, as well as their cross-references where applicable is given in informative Annex B.

3.1

automatic burner control system

protective system comprising at least a programming unit and all the elements of a flame detector device

NOTE The various functions of an automatic burner control system can be in one or more housings (see also 3.66). It is a protective system.

3.2

air pressure detector

device for sensing the existence of air pressure

3.3

air/fuel ratio

ratio between the mass flow of combustion air and the mass flow of the fuel

3.4

burner

combustion system under the control of individual automatic shut-off valves

3.5

burner, alternating pilot

pilot burner that is extinguished at the end of the main burner ignition period and is re-ignited immediately when the main burner is shut down for control purposes

3.6

burners, cross-ignited

group of burners designed and arranged such that, by means of their proximity and relative position, ignition of all burners can be ensured if one burner is ignited

3.7

burner, forced draught

burner in which the combustion air is supplied by mechanical means, usually of a fan or blower

3.8

burner, grate

solid fuel combustion system where the burning fuel is supported by a metallic grate

3.9

burner, induced draught

burner in which the combustion air is supplied by providing suction in the combustion chamber by mechanical means, usually a fan

3.10

burner input rate

highest quantity of fuel energy used by a burner in unit time corresponding to the volumetric or mass flow rates, the calorific value used being the net calorific value

3.11

burner, manual

burner whereby all the operating sequences are performed by an operator

3.12

burner, natural draught

burner in which the combustion air is entrained at atmospheric pressure, by the buoyancy of a chimney or the fuel velocity

3.13

burner, open firing

burner not requiring an enclosed combustion chamber

EXAMPLE Torches, work station burners, equipment-integrated burners, and other burners firing in the open.

3.14

burner, permanent pilot

pilot burner that is intended to be left on permanently

3.15

burner, pilot

independently controlled burner designed to ignite the main burner

3.16

burner, portable

burner designed to be capable of being transported to fire in different locations

3.17

burner, radiant tube

burner that heats up the IThE indirectly by means of firing into a radiant tube protruding into the IThE process chamber whereby the combustion remains wholly separated from the IThE process chamber

3.18

burner, work station

burner used at a particular work station and not requiring an enclosed combustion chamber

3.19

by-pass

passage conveying fuel from the upstream side to the downstream side of a pipework component so as to be independent of the action of the pipework component

3.20

calorific value

quantity of heat produced by the combustion of unit volume or mass of fuel at a constant pressure of 1 013 mbar

NOTE A distinction is made between the gross calorific value (where the water produced by combustion is assumed to be condensed) and the net calorific value.

3.21

combustion air

ambient air, or mixture of ambient air with other gases such as water vapour, carbon dioxide, ... that is used as oxygen supply for combustion process

3.22

combustion chamber

part of the IThE in which the combustion takes place

3.23

condensate drain

pipe designed to collect and drain condensates from a low point in the gas circuit and to drain it from a low point

3.24

control system

system which responds to input signals from the process and/or the operator and generates output signals which cause the process control to operate in the required way

3.25

EMC

immunity of the IThE to Electro Magnetic disturbances

3.26

enriched air

air with an oxygen concentration higher than 23 % (volume) obtained either by the addition of oxygen or the reduction of nitrogen content

3.27

explosion/pressure relief

device (e.g. a flange) containing a disc which is designed to yield safely to an unsafe increase of internal pressure

3.28

fault tolerance time

fault tolerance time is the time between the occurrence of an unsafe condition (caused by the process itself or due to equipment failure) and the point when the process changes into critical operation, which result in a hazardous event

3.29

filter/strainer, strainer/filter

device that enables foreign elements which could otherwise cause failures in the system, to be collected

3.30

flame response time

FRT

period of time that starts with the loss of sensed flame and ends with the de-energising of the terminals for the automatic shut-off valve

3.31

flame detector device

device by which the presence of a flame is detected and signalled

NOTE It can consist of a flame sensor, an amplifier and a relay for signal transmission.

3.32

flame sensor

actual flame-sensing element, the output signal value of which is used as the input for flame detector amplifier

3.33

flame trap or flame arrestor

device fitted to the pipe conveying gas or a gas-air mixture and whose intended function is to prevent the transmission of flame

3.34

flash back

flame propagation from the burner in upstream direction inside the pipework

3.35

fluids

gases, liquids and vapours in pure phase as well as mixtures thereof

NOTE A fluid contains a suspension of solids.

3.36

fluids group 1

fluids defined as explosive, extremely flammable, highly flammable, flammable (where the maximum allowable temperature is above flashpoint), very toxic, toxic, and/or oxidizing

3.37

fluids group 2

all other fluids not referred to as group 1 fluids

3.38

functional safety

capability of a safety system or other means to reduce risk, to execute the actions required for achieving or maintaining a safe state for the process and its related equipment

3.39

gas flow detector

device for sensing the presence of an adequate gas flow

3.40

gas pressure detector

device for sensing the presence of gas pressure

3.41

gas pressure regulator

device which maintains the downstream pressure constant to within fixed limits, independent of variations, within a given range, of the upstream pressure and/or flow rate

3.42

graded fuel

solid fuel in the form of lumps which are classified according to size

3.43

high temperature equipment

IThE operating at a temperature above 750 °C measured at the combustion chamber walls and/or the processing chamber walls

3.44

ignition

starting up chemical reaction of combustion of a fuel/combustion air mixture by application of a much smaller energy source

3.45

initial boiling point

temperature of a liquid fuel that is measured at the instant that the first drop of condensate falls from the lower end of the condenser tube in a boiling point test

3.46

lighting torch

hand-held burner which is used to ignite another burner

3.47

liquefied petroleum gas

LPG

commercial butane or commercial propane or any mixtures there of

3.48

lock-out, non volatile

safety shut-down by the protective system itself, such that a restart can only be accomplished by a manual reset

3.49

lower flammability limit

LFL

lowest concentration of fuel in air at which the air/fuel mixture is flammable

3.50

low temperature equipment

IThE operating at a temperature measured below 750 °C at any part of the combustion chamber walls and/or the processing chamber walls

3.51

main flame

flame, other than the ignition flame, on the main burner

3.52

manual reset

action after a lock-out of a safety related device (e.g. automatic burner control) carried out manually by the supervising operator

3.53

multiple burner equipment

IThE with several burners with a common air and gas pipework firing in a common combustion chamber

3.54

nominal size

DN

numerical designation of size which is common to all components in a pipework other than components indicated by outside diameter or by thread size

NOTE It is a convenient round number for reference purposes and is only loosely related to manufacturing dimensions. The nominal size is designated by DN followed by a number.

3.55

operating temperature

temperature, or range of temperatures, at which the IThE is designed to operate

3.56

operator supervision

circumstance by which an operator has continuous control and surveillance of the plant and is located in a position where he can shut the IThE down in the event of an emergency

3.57

pipework

assembly of piping (e.g. valve(s), orifice(s), ...) by means of which fuel and combustion air convey from the point(s) of supply to the burner(s)

3.58

piping

components intended for the transport of fluids, when connected together for integration into a pressure system

NOTE Piping includes in particular a pipe or system of pipes, tubing, fittings, expansion joints, hoses, or other pressure-bearing components as appropriate. Heat exchangers consisting of pipes for the purpose of cooling or heating air are considered as piping.

3.59

PLC

Programmable Logic Control

electronic device designed for control of the logical sequence of events

3.60

pre-purge

forced introduction of air or inert gas into the combustion chamber and flue passages, in order to displace any remaining fuel/air mixture and/or products of combustion, and which takes place between the start signal and the energising of the ignition device

3.61

pressure

pressure relative to atmospheric pressure, i.e. gauge pressure

NOTE As a consequence vacuum is designated by a negative value.

3.62

pressure accessories

devices with an operational function and having pressure-bearing housings

3.63

pressure equipment

vessels, piping, safety accessories and pressure accessories

NOTE Where applicable, pressure equipment includes elements attached to pressurized parts, such as flanges, nozzles, couplings, supports, lifting lugs, etc.

3.64

pressure, maximum allowable

PS

maximum pressure for which the equipment is designed, as specified by the manufacturer

NOTE It is defined at a location specified by the manufacturer. This is the location of connection of protective and/or limiting devices or the top of equipment or if not appropriate any point specified.

3.65

processing chamber

part of the equipment in which the workpiece(s) being processed is/are contained

3.66

protective system

equipment, units and safety related circuits whose main purpose is the protection of personnel, property and the environment

NOTE The protective system includes all the components required to carry out the safety function, for example sensors which monitor safety related parameters (e.g. flame monitoring), interruption device for the flow of fuel, ventilation of the body of the furnace and protection of the heated system (e.g. monitoring the temperature level). Typically a protective system consists of sensors, logic solving protective equipment and actuating elements. If this is achieved by multi-channel systems, then all channels and monitoring devices used for safety purposes are included within the protective system.

3.67

pulse firing

burner combustion system where the firing rate is controlled by the number and/or duration of burners firing at fixed heat input rates, e.g. high/low or on/off

3.68

pulverised fuel

solid fuel which has been grounded to a powder

3.69

purge point

plugged tapping at the extremities of a fuel pipework to facilitate purging

3.70

re-cycling

process by which, after a safety shut-down, a full start-up sequence is automatically repeated

3.71

remote reset

manual reset after a lock-out carried out from a location different from the safety related device

NOTE The connection between the place of reset and the safety related device on the IThE can be by electrical or electronic circuit. It complies with the single fault criterion.

3.72

safety accessories

devices designed to protect pressure equipment against the allowable limits being exceeded.

NOTE Such devices include:

- devices for direct pressure limitation, such as safety valves, bursting disc safety devices, buckling rods, controlled safety pressure relief systems (CSPRS), and
- limiting devices, which either activate the means for correction or provide for shutdown or shutdown and lockout, such as pressure switches or temperature switches or fluid level switches and 'safety related measurement control and regulation (SRMCR)' devices.

3.73

safe discharge area

zone which is safeguarded against the risk of combustion of discharged flammable gasses

3.74

safety shut-down

process which is effected immediately following the response of a safety device or the detection of a fault in the automatic burner control system and which puts the burner out of operation by immediately closing to the fuel shut-off valves and the ignition device

3.75

safety time

interval between a fuel valve being energised and another fuel valve being de-energised if the flame detector signals the absence of a flame

3.75.1

first safety time

interval between the pilot fuel valve, the start fuel valve or main fuel valve, as applicable, being energised and the pilot fuel valve, start fuel valve or main fuel valve, as applicable, being de-energised if the flame detector signals the absence of a flame

3.75.2

second safety time

interval between the main fuel valve being energised and the main fuel valve being de-energised if the flame detector signals the absence of a flame¹⁾

3.76

self-checking automatic burner control system

automatic burner control system designed so that the functioning of its safety-related parts are checked at suitable intervals

1) Definition used only if there is a first safety time applicable to either a pilot or start gas flame.

3.77

single burner equipment

IThE with one burner with a common air and gas pipework

3.78

spark restoration

process by which, following loss of flame signal, the ignition device will be switched on again automatically without total interruption of the fuel supply

3.79

start fuel

fuel supplied to the pilot or to the main burner at low rate prior to the start-up of the burner

3.80

start fuel flow rate

fuel flow rate during the start-up of the burner(s)

3.81

stoichiometric fuel rate

fuel rate at which, if reacted completely with the combustion air rate the fuel would just consume all the oxygen in the airstart fuel flow rate

3.82

system leak tightness check

way of controlling the leak tightness of a system by applying pressure to that system manually or automatically whereby the pressure shall not drop significantly within a given time frame

3.83

temperature, maximum/minimum allowable

TS

maximum/minimum temperatures for which the equipment is designed

3.84

test pressure

pressure to which pipework is submitted to a check for soundness

3.85

thermo-processing equipment

equipment in which material or workpiece is submitted to thermal energy

3.86

torch

manually controlled gas- or oil-fired open-flame tool or any mobile burner unit firing in the open and intended for use together with IThE

3.87

total closing time

interval between the occurrence of an unsafe condition and the automatic shut-off valves being in fully closed position

3.88

valve, automatic shut-off

valve which opens when energised and closes automatically when de-energised

3.89

valve, manual isolating

manually operated valve which is upstream of all other fuel controls to that IThE and by means of which the fuel supply to the IThE can be shut off

3.90

valve, manual shut-off

manually operated valve by means of which the fuel supply to an individual burner or to a group of burners can be shut off

3.91

valve, non-return

device to prevent the back flow of air, fuel, oxygen etc.

3.92

valve, pressure relief

valve or regulator designed to relieve excessive pressure

3.93

valve proving system

system to check the effective closure of automatic shut-off valves by checking leak tightness

NOTE It consists of a programming unit, a measuring device, valves and other functional assemblies.

3.94

Wobbe index

calorific value of a gas, on a volumetric basis, at specified reference conditions, divided by the root square of its relative density, at the same specified metering reference conditions

NOTE The Wobbe index is gross or net depending on whether the calorific value used is the gross or net calorific value.

3.95

zone

self-contained space within a IThE which is operating under the same conditions/parameters (e.g. temperature, pressure)

4 List of hazards

1 Cl.	2 Hazards	3 Location	4 Relevant clauses of Part 1	5 Relevant (sub)clause(s) of this European Standard
1	Hazards, hazardous situation and hazardous events			
	Mechanical Hazards			
1.1	High pressure fluid injection or ejection hazard	pipework	5.2.7	5.2.1.1, 5.2.2.4, 5.3.1.6, 5.6.10
2	Electrical Hazards			
2.1	Electrical contact direct or indirect with live parts	control system, power supply to the machine and connectors	5.3.2	5.2.6.1, 5.2.6.4, 5.3.6.1, 5.4.6, 5.7.2, 5.7.3, 5.7.4
2.2	Electrostatic phenomena		5.3.3	5.7.2, 5.4.1.3
3.	Thermal hazards, resulting in:			
3.1	Burns and other injuries by a possible contact of persons with objects or materials with an extreme high temperature, by flames or explosions and also by the radiation of heat sources.	Burners Environment of the IThE	5.4.1, 5.4.4	
3.2	Damage to health by hot working environment	Environment of the IThE	5.4.5, 6.4.15	
4	Hazards caused by interruption of energy supply			
4.1	malfunction or break up of components	Burner and accessories		5.2.2.3, 5.3.2.3, 5.4.3.2, 5.7.3
4.2	malfunction or break down of control system	Control system		5.7.3
4.3	unexpected start-up	Control system		5.2.5.3, 5.7.3
5	Hazards caused by (temporary) missing and/or incorrectly positioned safety related measures/means			
5.1	Specific hazard of maintenance and adjusting	burners, fans, piping, duct, control system		Clause 5
6	Hazards generated by materials and substances processed or used by the machinery			
6.1	Hazards from contact with or inhalation of harmful fluids, gases, mists, fumes, and dusts.	Exhaust gases evacuating system Combustion chamber		5.2.2.5, 5.2.2.6, 5.2.2.3, 5.3.3, 5.4.4
6.2	Fire or explosion hazard	burners, fans, piping, duct, control system Combustion chamber	5.4.3.1, 5.4.3.2	5.2.1.7, 5.2.1.9, 5.2.1.10, 5.2.1.11, 5.2.2.3, 5.2.3.2, 5.2.4.1, 5.2.4.2, 5.2.5.2, 5.2.5.3, 5.2.6.1, 5.2.6.2, 5.2.6.3, 5.3.1.9, 5.3.1.3, 5.3.1.6, 5.4.1.2, 5.4.1.4, 5.4.1.5, 5.4.1.6, 5.5.2, 5.5.3, 5.5.5, 5.5.10, 5.6, 6.2.3
7	Hazards generated by neglecting ergonomic principles in machinery design, as e. g. hazards from:			
7.1	Hazard of mismatch of design, location or identification of manual controls	Pipework Control system	5.12.2	5.2.2.1, 5.3.2.1, 5.4.3.1,

5 Safety requirements, measures and verification means

5.1 General

The safety goals of this European Standard shall include:

- choice of materials such that the construction and operation of the system are not detrimentally affected. In particular, all the components of the fuel pipework shall be capable of withstanding the mechanical, chemical and thermal loads to which they can be subjected during normal operation;
- reliable and correct time for ignition of the fuel/air-mixture at the burner(s);
- prevention of unintentional release of unburned fuels;
- shut-off fuel-supply in case of relevant fault;
- protection of pipeline by precluding the propagation of flame in reverse flow;
- prevent firing when the exhaust of combustion products is not ensured;
- prevent firing when the process conditions are not in the safe state.

Electrical circuits shall be designed in accordance with subclause 5.7 of EN 60204-1:2006.

The combustion and fuel handling for IThE shall comply with the safety requirements and/or protective measures of Clause 5.

Machinery shall comply with the safety requirements and/or protective measures of this clause. In addition, the machine shall be designed according to the principles of EN ISO 12100 for relevant but not significant hazards, which are not dealt with by this document.

NOTE For guidance in connection with risk reduction by design, see clause 4 of EN ISO 12100-2:2003, and for safeguarding measures see clause 5 of EN ISO 12100-2:2003.

5.2 Gaseous fuels

5.2.1 Gas pipework

5.2.1.1 General

The pipework design shall take into account the composition and properties (e.g. specific gravity) of the fuel gas and the need for venting, purging and cleaning.

The pipework material shall comply with the relevant standards.

For steel pipes, compliance with EN 10208-1 and EN 10208-2, EN 13480-2:2002 (Table A.3), or EN 10255 is considered appropriate. For copper pipes compliance with EN 1057 is considered appropriate. Copper Soldering connections shall not be used for gas carrying parts where the temperature is likely to exceed 100 °C.

Threaded pipe fittings shall comply with EN 10241 or EN 10242.

Metal is the preferred material for pipes and components but where appropriate and the same safety levels can be achieved then other materials can be utilized. Such materials and conditions of service shall be specified in the instructions for use.

Oscillations which may cause damage to pipework, components, safety systems shall be prevented (by firm anchoring and/or, use of flexible couplings).

5.2.1.2 Connections

Gas pipework connections shall be metallic and shall be of the threaded, compression, flanged, or welded types. Threaded connections shall be used only for the following pressure/diameter combinations:

- pressures up to 100 mbar, and diameters up to DN 80;
- pressures up to 2 bar, and diameters up to DN 50;
- pressures up to 5 bar, and diameters up to DN 25;
- pressures up to 10 bar, and diameters up to DN 15

For other combinations of pressures and diameters connections shall be by means of welded flanges or welded joints. The number of connections shall be kept to a minimum.

Where the equipment has a threaded connection, this thread shall comply with ISO 228-1 or ISO 7-1 as appropriate. In the case of threads according to ISO 228-1 the tightness shall be ensured by a ring gasket. Sealants for threads according to ISO 7-1 shall comply with EN 751, Part 1 or Part 2 as appropriate. Hemp shall not be used in threaded connections unless re-inforced with a suitable sealant.

Other threaded connections shall only be used providing they ensure tight connections and are suitably identified.

The design of pipework shall be such as to avoid tensile loading of the joints.

Compression fittings shall comply with EN ISO 8434-1 or EN ISO 19879. They shall only be used for pressures up to 5 bar and diameters up to 42 mm.

Any pipe passing through an unventilated space shall not have a connection except welded joints.

Flanges shall comply with ISO 7005, Parts 1 and 2 as appropriate.

Arc welding shall comply with EN ISO 5817, quality Level C.

5.2.1.3 Unconnected pipework

Any unconnected pipework shall be plugged, capped or blank flanged by means of metallic parts.

5.2.1.4 Galvanic cells

The formation of galvanic cells shall be avoided by suitable choice of materials.

5.2.1.5 Flexible tubing and couplings

Flexible tubing shall comply with the general requirements of 5.2.1.1, together with the following:

- shall be as short as possible;
- shall be suitable for the maximum and minimum working temperatures;
- shall be suitable for a pressure 1,5 times the working operating pressure (with a minimum of 150 mbar), at the maximum and minimum working temperatures;
- shall have a directly accessible, upstream shut-off valve;

- shall be mounted in such a way as to avoid distortion, whiplash and damage;
- shall have end fittings as integral parts of the tubing;
- shall be constructed from suitable material both metallic and/or non metallic selected for the application duty and not be easily damaged.

Couplings for removable equipment shall ensure a gastight connection with the equipment connected and disconnected.

5.2.1.6 Marking

The pipework shall be identified as gas pipework.

NOTE Identification of gas pipework is dealt with by national regulations.

5.2.1.7 Soundness

The gas pipework shall be tight and shall be designed to withstand the internal pressure.

The external leakage rate shall not give rise to a dangerous condition, flammable and/or toxic, in the foreseen circumstances of the equipment installation. The frequency of testing to determine the external leakage shall be specified in the instruction handbook.

NOTE It is generally agreed that an external leak rate of $\sim 1 \text{ dm}^3(\text{n})/\text{h}$ will not give rise to a dangerous condition in typical ventilated industrial installations. The actual leak rate will depend upon the volume, number of connections, test gas, number of valves and component parts contained.

The external leak rate test method shall take into account the volume, number of connections, test gas, number of valves and component parts contained and temperature. Methods of testing shall include spray bubble leak identification and/or pressure decay test.

5.2.1.8 Condensate drains

In cases where condensates can create a hazard, means shall be provided at the lowest points of the equipment for draining any condensate. When moist gases are being used, condensate drains of a suitable type shall be installed. Any condensate drains, siphons, etc. shall be in a position such that they can be easily checked. Flammable condensates shall be collected by an appropriate means (e.g. piped into a container).

Valves in condensate drains shall be suitably plugged, capped or blank flanged by metallic parts.

5.2.1.9 Purge points

Means shall be provided to facilitate purging of the gas system during commissioning and maintenance to prevent the build up of flammable substances.

5.2.1.10 Blow-off and breather pipes or conduits

Where blow-off or breather pipes or conduits are fitted on regulators or relief valves or vent valves, adequate means shall be provided to facilitate the venting of gas from the system to a safe discharge area.

In case breathers or blow-off pipes are gathered, the cross section of the collector shall be suitable to evacuate simultaneously total flow rates of the exhaust sources.

5.2.1.11 Pressure relief devices and flame arrestors on pipework

For equipment designed for situations in which flash-backs can occur, flame arrestors and/or pressure relief devices shall be fitted.

Pressure relief devices shall be designed to yield at a pressure below the design pressure of the pipework and shall be positioned such that the discharge flow and the pressure relief device does not constitute a risk to the equipment, personnel or third parties.

A flash-back at least shall trigger an alarm. The required measures after a flash-back shall be described in the instruction for use.

5.2.1.12 Pressure oscillations

The gas pipework shall be designed so as to avoid the possibility of gas velocities and pressure fluctuations causing oscillations which could cause damage to pipework, components or safety systems (e.g. by designing the correct sizing of pipe, using pressure regulator).

5.2.1.13 Equipment supplied with different fuel gases

Where a burner is intended for use with more than one gaseous fuel, means shall be provided to ensure that the supply pipework of the gas not being fired is positively isolated.

5.2.1.14 By-pass

By-passes shall not be fitted in parallel with any item of safety equipment.

This requirement shall not apply to valve proving systems (EN 1643) nor to system leak tightness checks on automatic shut-off valves.

5.2.1.15 Isolation of required safety devices

Required safety devices (e.g. pressure switches, relief valves, ...) shall not be isolated from the equipment they protect during start-up or operation of the burner. In case isolating valves can not be avoided and are mounted between these required devices and the main lines, these isolating valves shall be locked in the open position during operation of the equipment by adequate means (e.g. manual lock, ...). Operation with the isolation valves not in the fully open position shall not be possible.

5.2.2 Required safety devices

5.2.2.1 Manual isolating valve

A manually operated isolation valve shall be fitted upstream of the first control device in the gas circuit. Manual isolation valves shall be so designed or positioned as to prevent inadvertent operation but shall be easily accessible and capable of rapid operation when required.

If technically applicable, only manual isolating valves complying with EN 331 shall be fitted. For valves outside the scope of EN 331, the safety requirements detailed in EN 331 shall be met at an equivalent level.

They shall be so designed that the "OPEN" and "CLOSED" positions are readily distinguishable (e.g. a 90° turn valve if applicable and available).

5.2.2.2 Filter/strainer

Special care shall be taken to prevent the ingress of particles, either from the pipework or from the gas, which would be detrimental to the operation of the equipment by the incorporation of a suitable filter or strainer immediately downstream of the first manual isolating valve of the IThE. Additional filters/strainers may be required (e.g. immediately upstream of the automatic shut-off valve). The filter and/or the strainer shall be positioned in such a way that periodic servicing remains easy.

In the event of the installation of a by-pass to the filter and/or the strainer, an identical filtering device shall be installed on the by-pass line.

Filter and/or the strainer shall be checked at intervals specified in the instruction handbook.

5.2.2.3 Automatic shut-off valves

5.2.2.3.1 General

Automatic shut-off valves shall be in accordance with the following subclauses of EN 161:2007:

- for general requirements: subclause 7.1
- for leak tightness: subclauses 7.2 and 7.3,
- for durability: subclause 7.8,
- for the closing function: subclause 7.9,
- for the closing force: subclause 7.10,
- for the closing time: subclause 7.12
- for the sealing force: subclause 7.13.

The automatic shut-off valve shall endure the intended cyclings in the IThE.

Valves construction and materials shall be suitable for the used gas composition.

Automatic shut-off valve shall be capable of withstanding back pressure and differential pressure under all process circumstances.

Low cycling applications intended to operate continuously for periods longer than 1 year shall have a redundant safety shut-off system at least comparable with the flow sheet given in Figure C.5 that allows testing the effective closure of the valves at least once a year.

High cycling applications (e.g. over 10 000 cycles/year, e.g. pulse firing, ...) shall use only valves that are specified capable of an increased number of cycles. The instruction handbook shall specify the need to check valves for correct operation, the procedure to be adopted and the intervals at which this should be carried out.

5.2.2.3.2 Single burner equipment

The gas supply to the burner shall be under the control of two class A automatic shut-off valves of EN 161 in series in the gas pipework.

For natural draught burner with a controlled capacities below 70 kW there shall be at least two class B valves of EN 161.

A thermo-electric flame supervision device complying with EN 125 is acceptable for natural draught burners operating in open air with controlled capacities below 70 kW and for natural draft burners operating in combustion chamber with controlled capacities below 2,5 kW.

The automatic shut-off valves shall not open or shall shut off the fuel to the burner when the limit of any safety condition is reached. The following conditions shall be taken into account:

- minimum and maximum gas flow;
- minimum and maximum gas pressure;
- minimum and maximum air flow;

- minimum and maximum air pressure;
- failure of power supply and/or other utilities (e.g. compressed air, steam);
- failure of heat transfer fluid;
- fume extraction malfunction;
- maximum operation temperature of IThE;
- minimum and maximum combustion chamber pressure;
- flame failure;
- failure of system leak tightness check and/or valve proving system;
- incorrect air/gas ratio as referred in 5.2.3.3.

In these cases the automatic shut-off valves shall be de-energised by a protective system.

This function shall meet the requirements of the protective system according to 5.7.2 and 5.7.3.

NOTE In addition there may be processes and/or machine conditions that can cause a risk if the burner continues to fire. However these conditions are not covered by this standard.

It shall only be possible to manually reset the lock-out (see 3.48) of a closed automatic shut-off valve.

For typical examples of piping and components see informative Annex C.

5.2.2.3.3 Multiple burner equipment

The gas supply to each burner or group of burners shall be under the control of two class A automatic shut-off valves of EN 161 in series in the gas pipework.

For natural draught burner with a controlled capacities below 70 kW there shall be at least two class B valves of EN 161.

A thermo-electric flame supervision device complying with EN 125 is acceptable for natural draught burners operating in open air with controlled capacities below 70 kW and for natural draft burners operating in combustion chamber with controlled capacities below 2,5 kW.

For multiple burner installations, the individual burner shut-off valve shall be considered as one of the automatic shut-off valves specified above provided it is at least of the same class. For typical examples of piping see informative Annex C.

The automatic shut-off valve(s) shall not open or shall shut off the fuel to the entire IThE or independent zone when the limit of any safety condition is reached. The following condition shall be taken into account:

- minimum and maximum gas flow;
- minimum and maximum gas pressure;
- minimum and maximum air flow;
- minimum and maximum air pressure;
- failure of power supply and/or other utilities (e.g. compressed air, steam);

- failure of heat transfer fluid;
- fume extraction malfunction;
- maximum operation temperature of IThE;
- minimum and maximum combustion chamber pressure;
- flame failure;
- failure of system tightness check and/or valve proving system;
- incorrect air/gas ratio as referred in 5.2.3.3.

In these cases the relevant automatic shut-off valves shall be de-energised by a protective system.

This function shall meet the requirements of the protective system according to 5.7.2 and 5.7.3.

NOTE In addition there may be processes and/or machine conditions that cause a risk if the burner continues to fire. However these conditions are not covered by this standard.

It shall only be possible to manually reset the lock-out (see 3.48) of a closed automatic shut-off valve.

Flame failure or process control shut-down shall cause the closing of two automatic shut-off valves piped in series except in the following cases where single individual burner shut-off valve is sufficient:

- in case of high temperature equipment;
- in case of low temperature equipment providing the following conditions complied with:
 - a system leak tightness test to ensure that the individual burner automatic shut-off valves are closed is conducted at each start up of the IThE or other specific test period of the burner group and this shall not be less than once per week; and
 - dilution of gas leakage (at full burner capacity) of one valve is under 25 % of LFL, achieved by fresh air or flue gas considering all modes of operation (maximum power and part load of the heating system as well as variation of the LFL with furnace temperature).

For typical examples of piping and components see informative Annex C.

5.2.2.3.4 Valve proving system

Automatic shut-off valves controlling capacities greater than 1 200 kW shall be equipped with a valve proving system. If this is applicable, then the valve proving system shall comply with EN 1643 or give an equivalent level of safety.

The signal of a leaking valve from the valve proving system shall stop the current start-up when the test takes place during start up or prevent the next start-up when the test takes place after shut down.

This function shall meet the requirements of a protective system according to 5.7.2 and 5.7.3.

5.2.2.4 Gas pressure regulator

A gas pressure regulator shall be incorporated where this is necessary for control of the pressure and the flow rate.

Gas pressure regulators, when fitted, shall comply, with EN 88 or with EN 334 as appropriate.

If the outlet side of the gas pressure regulator and/or the following line section with equipment up to the burner is/are not designed for the maximum supply pressure (inlet upstream pressure to the gas pressure regulator under fault conditions) the following measures shall be applied shutting off the gas supply before an excessively high pressure occurs:

- an over pressure cut off device shall be applied upstream of the gas pressure regulator. This device shall comply with EN 14382;
- the over pressure cut off device shall be designed via an overpressure switch according EN 1854 combined with a safety shut-off valve of EN 161;
- if an over pressure cut-off device is installed a small capacity relief valve shall always be applied downstream of the gas pressure regulator to vent small leakages of the high pressure cut-off.

Pressure adjustment on the gas pressure regulator shall only be possible with a special tool provided for the task.

5.2.2.5 Air and gas flow and pressure detectors

5.2.2.5.1 Air

Equipment fitted with forced or induced draught burner(s) shall be fitted with devices for proving adequate air flow during the pre-purge, ignition and operation of the burner. Air flow failure at any time during the pre-purge, ignition or operation of the burner shall cause safety shut-down and, in the case of no operator supervision, shall cause a lockout.

This function shall meet the requirements of the protective system according to 5.7.2 and 5.7.3.

The air-proving device shall be checked in the 'no flow' state prior to start-up (e.g. by stopping the combustion air supply or by interrupting the air signal to the device(s) in such a way as to simulate stopping the combustion air supply). Failure to prove the device in the "no flow" condition shall prevent start-up.

Air flow shall be monitored:

- by pressure detectors or
- by flow detectors.

It has to be shown that any of these devices provide satisfactory and reliable proof of the flow for all operating conditions.

This requirement shall not apply to portable gas burners, work station burners and equipment-integrated burners with open flame, supervised continuously by trained operators, and having a maximum burner input rating below 70 kW.

Air pressure detectors shall comply with EN 1854.

5.2.2.5.2 Gas

5.2.2.5.2.1 Low gas protection

Low gas pressure protection to prevent insufficient gas flow shall be fitted.

The low gas pressure protection device has to provide satisfactory and reliable proof of the flow for all operation conditions.

The system shall prevent start-up or cause safety shut-down or, in the case of no operator supervision, lock-out (see 3.48) in the event of pressure falling below a pre-determined value.

This function shall meet the requirement of the protective system according to 5.7.2 and 5.7.3.

Gas pressure detectors shall comply with EN 1854.

5.2.2.5.2.2 High gas protection

High gas pressure protection to prevent excessive gas flow shall be fitted in all circumstances except when:

- the equipment supply pressure does not exceed 100 mbar; and
- the pressure drop across the gas pressure regulator is less than 30 % of the normal operating minimum outlet pressure; and
- regulator failure does not result in an unsafe start-gas rate being obtained; and
- the equipment capacity is below 600 kW.

Where high gas pressure protection is required, the system shall prevent start-up or cause safety shut-down or, in the case of no operator supervision, lock-out (see 3.52) in the event of a pre-determined pressure being exceeded.

This functions shall meet the requirement of the protective system according to 5.7.2 and 5.7.3.

Gas pressure detectors shall comply with EN 1854.

5.2.2.6 Flue gas venting

Flue gases shall be vented in a safe way.

IThE with a closed combustion chamber or combustion chamber with at least three surrounding walls shall be equipped with a flue system. The cross sectional area of the flue system shall be calculated according to volume, pressure and temperature of the flue gases (products of combustion, excess air and process emissions).

For IThE's equipped with natural draught burners the flue system shall be fitted with an appropriate draught break, above the height of the operator, or control damper (typical example of a draft break see informative Annex C, Figure C.6).

If the flue gases are extracted by a fan or the draught is controlled by a damper, the system shall be fitted with a safety device to effect a safety shut-down of the burner(s) or a switching over to a backup duct system in the event of a failure in the flue venting. This function shall meet the requirement of the protective system according to 5.7.2 and 5.7.3.

For all IThE equipment burners supplied without a flue system the combustion products shall be directed away from the workplace. The instructions for use shall refer to the need for sufficient venting to ensure the correct air quality for the operator.

NOTE 1 EN 525 gives useful information on maintaining the air quality in workshops.

NOTE 2 Local regulations may apply.

5.2.2.7 Ignition system

Where the gas for the pilot burner is taken from upstream of the gas pressure regulator to the main burner(s), the pilot burner shall be equipped with an appropriate gas pressure regulator complying with 5.2.2.4.

For safety requirements pilot burner(s) shall be treated as main burners and 5.2.2.1, 5.2.2.2, 5.2.2.3, 5.2.2.4 and 5.2.2.5 shall apply.

Any direct ignition device or combination of the ignition device and the pilot burner in automatic installations shall form an integral part of the main burner system.

In the case of installations for controlled manual operation, the ignition assembly shall be capable of being mounted on the main burner in one way only and in such a way that it occupies a fixed position with respect to the burner to be ignited.

The construction and location of a pilot burner shall be such that, under all operating conditions, the ignition flame remains stable and of such a shape that the main flame is ignited.

The ignition device shall be reliable and of sufficient capacity, so that immediate, low noise and smooth ignition is obtained.

Where use is made of a portable pilot burner or ignition device:

- the pilot burner or ignition device shall be capable of being fitted in one way only. If necessary the correct position shall be monitored;
- the connections for fuel, air and ignition energy shall be so designed that a reliable link-up is obtained, and errors of fitting of connections are avoided.

5.2.2.8 Individual manual shut-off valves for burners

For burners which are independently ignited, each individual burner shall be fitted with a manual shut-off valve.

The manual shut-off valve shall comply with EN 331. For valves outside the scope of EN 331, the safety requirements detailed in EN 331 shall be met at an equivalent level.

However if the installation of such a manual valve affects the mixing characteristics of mixing devices (e.g. venturi mixers), then the shut-off valve shall be installed upstream of any such device.

For multiple burners in which cross-ignition from burner to burner occurs by design the complete group of burners shall be fitted with at least one manual shut-off valve.

5.2.3 Combustion air and pre-purging the combustion chamber and flue passages

5.2.3.1 Combustion air system

The pipework to be designed shall take into account the properties of combustion air.

All manual control devices (registers, valves, etc.) for the air shall be set in their pre-determined positions and protected against inadvertent movement.

The location of the combustion air intake shall be such as to prevent entry of exhaust products, unless provided for by the design (e.g. for reduction of emission of nitrogen oxides (NO_x)).

The ventilation of IThE shall be such as to allow an adequate supply of process air and combustion air to reach the burner(s) under all conditions.

NOTE Attention should be paid to sufficient air supply to the IThE. For many application it is recommended to install an air inlet filter with filter monitoring to achieve reliable operation of the installation.

The combustion air system shall be designed in a manner that prevents the back-flow of furnace atmosphere through combustion equipment.

The air circuit shall be designed so as to avoid oscillations that may lead to material defects.

5.2.3.2 Pre-purging of the combustion chamber

Except where specified below, start up or re-start after a lock-out (see 3.48) shall not be initiated until adequate steps have been taken to ensure that no combustible mixture is present in the combustion/processing chamber, connected spaces and flue products evacuation circuit (heat exchangers, dust extractors). This condition shall be achieved by means of a period of pre-purging immediately prior to ignition or within a time to be specified in the instruction handbook.

The pre-purge time shall be such as to ensure that the concentration of any combustible products in any part of the combustion chamber/connected spaces and flue duct is below 25 % of the LFL of the fuel gas; this being calculated with the combustion chamber/connected spaces and the flue duct assumed as being initially filled up with flammable gases.

In general, five complete air changes of the combustion chamber/connected spaces and flue duct will suffice. The air flow rate used for a pre-purge shall be at least 25 % of the maximum combustion air flow rate. In the case of natural draught, the condition to achieve the above requirements shall be defined in the instruction handbook.

Inert or non flammable gases shall be used instead of air if required by the equipment or process. Other methods of ensuring that the combustion chamber and connected spaces do not contain flammable gases can be utilized providing that the equivalent level of safety is achieved.

The pre-purge time and purge procedure and or methodology shall be specified in the instruction handbook.

The system for ensuring correct pre-purge time and the airflow shall meet the requirements of a protective system according to 5.7.2 and 5.7.3.

In the following cases the pre-purge shall be omitted:

- a) in applications where the presence of free oxygen can be a risk (e.g. flammable atmosphere) or shall affect the equipment (e.g. graphite crucible) or the product quality; additional precautions shall be taken to prevent gas leakage across the automatic shut-off valves by using two class A valves of EN 161 and a valve proving system;
- b) when the combustion chamber is proved to be at a temperature above 750 °C (as defined for high temperature equipment);
- c) when re-cycling a burner after shutdown for control purposes, pre-purging is not required in the following different cases:
 - where the burner is fitted with an independently supervised permanent or alternating pilot;
 - where the burner is fitted with two class A valves of EN 161, that close simultaneously and are equipped with a valve proving system. The valve proving system is not required for pulse fired burners;
 - with pulse fired burners if the burner shut-off valve is certified by the supplier to be suitable for the increased number of cycles typical of pulse firing;
 - in multiple burner systems when one or more burners remain alight provided that not more than one burner is extinguished due to flame failure;
 - when the combustion chamber is proved to be at a temperature above 750 °C (as defined for high temperature equipment) at any point where a flammable mixture coming from the burner(s) will ignite without delay;
- d) in the case where one burner of a group of radiant tube burners has been locked-out maximum of one re-start is permitted before lock-out (see 3.48) after a flame failure, if:

- each burner has an automatic burner control system; and
- the ignitable fuel-air-mixture inside the exhaust system is below 25 % of the LFL or the radiant tube, the burner and the connection to the exhaust are designed for the maximum pressure increase that is possible during ignition; and
- the gas supply to each radiant tube burner is equipped with automatic shut-off valve class A of EN 161.

5.2.3.3 Air/gas fuel ratio

The air mass flow rate shall always be in a ratio with the gas mass flow in order to ensure safe ignition and that throughout the operating range, a stable and safe combustion is maintained at each individual burner. The ratio needs not be the same value at all operational conditions.

The design of the air/gas ratio control has to consider process conditions as well as fuel and combustion air properties. Defect or malfunction should effect that the system will tend towards higher excess air or proceed to lockout if the air/gas ratio results in an unsafe condition.

Pneumatic gas/air ratio controls shall comply with EN 12067-1 or EN 12078 if applicable.

Electronic gas/air ratio controls shall comply with EN 12067-2 if applicable.

To ensure their reliability, air/gas ratio controllers shall be used in conditions (temperature, pressure, flow rate) for which they have been designed. These conditions and instructions for maintenance shall be specified in the instruction handbook.

In case other methods/technologies are used for the ratio control and depending on the combustion air and fuel gas properties, additional protective measures shall be required (e.g. in case of frequency control of the combustion air blower, preheated combustion air, variable Wobbe index of the gas). The air/gas ratio control function shall meet the requirement of the protective system according to 5.7.2 and 5.7.3.

NOTE The combination of any ratio control (pneumatic or other) in combination with a flame supervision system that detects all possible incorrect ratios is generally considered to be sufficient protection.

5.2.4 Supply of pre-mixed fuel gas/air

5.2.4.1 Mixture pipework

The mixture pipework volume shall be as small as possible. The system shall be designed so as to provide a sufficiently high mixture flow velocity such that flame propagation upstream cannot occur, or shall be fitted with a flame trap/arrestor or pressure relief devices.

Alternatively, the system shall be fitted with a sensor which causes lock-out in the event of the flow velocity falling below a pre-determined limit or a temperature sensor which causes lock-out in the event of flash-back (see 3.48).

These devices are not required for burners where the manufacturer can demonstrate that flash-back cannot occur in any circumstances (e.g. pilot burners with their own mixing devices).

5.2.4.2 Air and gas supply to the mixture circuit

The presence of fuel gas/air mixture in the pipework supplying either fuel gas or air to the mixing device, whether due to reverse flow of the mixture, ingress to either feed or to internal leakage, shall be prevented.

If a non-return valve is used for this purpose and if it is not resistant to flashback, then an additional high gas pressure switch located downstream of this non-return valve shall be incorporated to shut off the flow of fuel gas to the equipment by means of the relevant automatic shut-off valves specified in 5.2.2.3 in the event of a flame flashback.

A flash-back shall trigger an alarm. The required measures after a flash-back shall be described in the instruction for use.

5.2.5 Burners

5.2.5.1 Main burners

All burners shall be suitable for the working conditions and shall provide operating safety for:

- the fuels used (type, pressure, etc.);
- the operating conditions (pressure, temperature, atmosphere, etc.);
- the nominal input rate and range of regulation (maximum and minimum capacity);
- ease of visual monitoring (sight glasses, sight holes, etc.).

5.2.5.2 Radiant tube burner system

Radiant tubes burner system shall be suitable and allow safe operation.

Radiant tube burner systems shall be designed in accordance with the requirements for a protective system in accordance with 5.7.2 and 5.7.3.

They shall:

- be constructed of suitable materials for the thermal input rate, temperature and furnace atmosphere;
- minimise the probability of combustion products having contact with the furnace atmosphere;
- shall be equipped with an automatic burner control system according to 5.2.6. At temperatures above 750 °C no automatic burner control system is needed if a safe ignition of the air/gas mixture can take place. The temperature limit of 750 °C shall be detected at the coldest point;
- if additional burners are required to operate the IThE processes above 750 °C and an automatic burner control systems is not required then they shall be isolated from the supply by automatic shut-off valves that are controlled in accordance with the requirements of a protective system (according to 5.7.2 and 5.7.3) that will not permit fuel to flow until the temperature at the ignition point within the radiant tube is above 750 °C.

Because the ignition point is inside the radiant tube and the temperature inside the tube may well be much lower than in the chamber in which the radiant tube is placed this temperature difference shall be taken into consideration when designing.

5.2.5.3 Start-up and ignition

5.2.5.3.1 Start-up

Start-up of the fuel supply and burner(s) shall be possible only when:

- a) the installed air and fuel gas proving devices (e.g. air flow, gas pressure, system leak tightness check) have been checked to ensure that they are in the correct operating condition for start-up;
- b) all relevant interlocks (e.g. burner(s) position, valve(s) position, flue damper(s)) have been proved to be in the correct position.

5.2.5.3.2 Start fuel flow rate

The energy released during the start-up of the burner(s) shall be limited so that the maximum pressure rise from ignition shall not cause any damage to the IThE (see Table 3).

The start fuel flow rate shall be controlled by a protective system according to 5.7.2 and 5.7.3.

Where the burner is ignited manually (e.g. by means of a lighting torch) and has a burner input rate in excess of 70 kW, it shall be equipped with a means of limiting the start-up gas.

5.2.5.3.3 Ignition

The ignition process shall be initiated immediately or within a time to be specified in the instruction handbook after the conclusion of the pre-purging stage.

Where the main burner is ignited by means of a pilot burner, the gas supply to the main burner shall be shut off during the pre-purge and ignition of the pilot burner. The automatic shut-off valve(s) of the main burner shall open only when the pilot burner flame has been proved.

NOTE Where air enriched with oxygen or oxygen alone is the oxidising agent for the combustion of a gas, (commonly called oxy/fuel firing), then the ignition procedures and times for such systems may require specific additional design attention to ensure the equivalent levels of safety.

5.2.5.3.4 Safety time

5.2.5.3.4.1 General

The safety time and total closing time shall not vary by more than 20 % when the electrical supply voltage is varied between 85 % and 110 % of the nominal value.

5.2.5.3.4.2 Maximum safety times for natural draught burners

The safety time and total closing time for natural draught burners shall not exceed the values given in Tables 1 and 2.

Table 1 — Maximum safety times for natural draught burners operating in open air

Burner input rate kW	Safety time s	Total closing time s
1) Thermoelectric flame supervision device (EN 125)		
up to and including 70	60	45
2) Flame supervision device other than thermoelectric (EN 298)		
up to and including 70	10	10
above 70 up to and including 360	10	3
above 360 ^{*a}	5	3
^{*a} Ignition at a rate of 33 % of the burner input rating with a maximum of 350 kW.		

Table 2 — Maximum safety times for natural draught burners operating in combustion chamber

Burner input rate kW	Safety time s	Total closing time s
1) Thermoelectric flame supervision device (EN 125)		
up to and including 2,5	60	45
2) Flame supervision device other than thermoelectric (EN 298)		
up to and including 70	10	10
above 70 up to and including 360	10	3
above 360 ^{*a}	5	3
^{*a} Ignition at a rate of 33 % of the burner input rating with a maximum of 350 kW.		

5.2.5.3.4.3 Maximum safety times for forced and induced draught burners

The maximum start gas rate and the corresponding safety time for forced and induced draught burners shall not exceed the values given in Table 3.

The total closing time shall not exceed 3 s.

Burner start-up shall be achieved in accordance with one of the following methods:

- direct ignition of the main burner at full rate (see Table 3, Column 2); or
- direct ignition of the main burner at reduced rate e.g. by using slow opening valve; (see Table 3, Column 3); or
- direct ignition of the main burner at reduced rate with by-pass start gas supply to a separate gas inlet of the burner or two step safety valve; (see Table 3, Column 4); or
- ignition of the main burner by means of an independent pilot burner; (see Table 3, Column 5).

For methods of burner start-up see Annex D.

Higher start gas rates than those specified in Table 3 may be achieved at the end of the safety time provided that it is proved that the total amount of energy released in the combustion chamber during the safety time is not greater than the energy release calculated by multiplying the values of maximum start gas heat input and safety time given by Table 3.

Table 3 — Maximum safety times for forced and induced draught burners

1	2	3	4	5
\	Direct main burner ignition at full rate	Direct main burner ignition at reduced rate with slow opening valves	Direct main burner ignition at reduced rate with by-pass start gas supply	Main burner ignition with independent pilot burner
Rate $Q_{F\ max}$ kW	Safety time t_s s	Safety time t_s s	Rate Q_{ST} kW	Safety time t_s s
≤ 70	5	5	≤ 70	5
> 70 ≤ 120	3	3	≤ 70	5
			> 70 ≤ 120	3
> 120 ≤ 360	not allowed except as described below	3	≤ 70	5
			> 70 ≤ 120	3
			> 120 ≤ 360	not allowed
> 360	not allowed	not allowed	$Q_{ST} = 120\ kW$ or $t_s * Q_s < 100$ (max. $t_s = 3\ s$)	5 ($Q_{ST} \leq 70\ kW$) 3 ($Q_{ST} > 70\ kW$)
$Q_{F\ max}$ = maximum main burner input rate in kilowatts Q_{ST} = start input rate in kilowatts Q_s = maximum start input rate expressed as a percentage of $Q_{F\ max}$ ($Q_s = Q_{ST} / Q_{F\ max}$) t_s = safety time in seconds				

Only if required for process reasons or special cases of equipment construction and if the above mentioned ignition safety times cannot be used the function and values of the ignition safety time shall differ from those given in Table 3 provided the safety of the IThE is not endangered. In this case, the ignition safety times shall not exceed the values:

$$t_s < P_v / (B_v \times 1,7 \times Q_s)^2$$

where

t_s is the safety time in s;

B_v is the combustion chamber full load (MW/m^3), with a minimum of $0,015\ MW/m^3$;

Q_s is the maximum start gas heat input expressed as a percentage of $Q_{F\ max}$: ($0 < Q_s < 100$);

P_v is the allowable combustion chamber pressure (mbar) minus combustion chamber back pressure during ignition (mbar).

Where for process reasons, burners with a nominal input exceeding 120 kW are ignited directly at full rate or burners with a nominal input exceeding 360 kW are ignited directly, at reduced rate using slow opening valves

2) This formula is typical for natural gas, LPG and comparable fuels (e.g. not for fuels containing high amounts of hydrogen) firing with cold combustion air with 21 % Oxygen content.

the combustion chamber/process chamber, flue ways and pipework shall be designed to take account of the maximum pressure rise.

In any case, the safety time and total closing time shall not exceed 10 s. In the case of long cross-ignited burners, an extension of the safety time of 1,5 s/m of burner length, with a maximum of 10 s is acceptable providing the flame is monitored at the end of the burner remote from the source of ignition and safe ignition always takes place.

5.2.5.3.5 Flame failure

5.2.5.3.5.1 Flame failure on start-up

In the event that flame failure occurs during the safety time, the burner shall go to lock-out (see 3.48).

However, re-cycling is acceptable providing equipment safety is not compromised. The number of re-cycles shall not exceed 2. The control of the re-cycle(s) shall be designed in accordance with the requirements for a protective system according to 5.7.2 and 5.7.3. If there is no flame signal at the end of these re-cycles, the failing burner shall go to lock-out (see 3.48). The conditions of and the time period between recycle and the number of re-cycles shall be specified in the instruction handbook.

For pulse firing burners, flame failure of a single burner shall cause safety shut-down instead of lock-out. Three consecutive flame failures shall cause lock-out. The total number of burners subject to this provision shall be limited to comply with 5.2.5.3.1 (see 3.48). The number of burners shall be specified in the instruction handbook.

5.2.5.3.5.2 Flame failure during operation

In the event of flame failure during operation the burner shall go to lock-out (see 3.48).

However, in certain cases, safety shut-down is acceptable providing equipment safety is not compromised. Not more than one re-cycle shall be permitted, the conditions for which shall be specified in the instruction handbook. If there is not a flame signal at the end of this re-cycle, the failing burner shall go to lock-out (see 3.48)

The IThE shall be designed such that a recycle of a single burner system requires a complete recycle including pre-purge.

5.2.5.4 Burner capacity control

In any combustion system, the turndown ratio shall be such that the burner(s) is/are fully stable at all firing conditions.

5.2.5.5 Permanent pilots

Where used in the case of main burners supplied with gas or combustible vapours with uncertain combustion characteristics, e.g. varying calorific value, permanent pilots shall be independently supplied with a clean fuel gas of constant quality and be fitted with automatic burner control systems.

5.2.6 Automatic burner control systems

5.2.6.1 General

The main flame and, if applicable, the pilot burner flame, shall be supervised by means of an automatic burner control system. Exceptions are only permitted when equipment safety is not compromised (e.g. see 5.2.6.2 and 5.2.6.3).